21 January 2015

CRUISE RESULTS
NOAA Research Vessel ***PISCES***
Cruise No. PC 14-05
Fall Northeast Pelagic-Ecosystem Monitoring Survey

CRUISE PERIOD AND AREA

The NOAA research vessel *PISCES* sampled at a total of 155 stations from 3 to 19 November 2014. With good weather for most of the cruise period, and with the vessel steaming at 12 knots or more between stations, the cruise attained excellent coverage of all the survey areas, with every station but one in the Mid-Atlantic Bight, being sampled. In addition, there were two midwater trawls conducted almost every day.

OBJECTIVES

The principal objective of the survey was to assess the pelagic components of the Northeast U.S. Continental Shelf Ecosystem from water currents to plankton, pelagic fishes, marine mammals, sea turtles, and seabirds. The spatial distribution of the following parameters was quantified: water currents, water properties, phytoplankton, microzooplankton, mesozooplankton, pelagic fish and invertebrates. Both traditional and novel techniques and instruments were used. In essence, the approaches of the Ecosystem Monitoring survey and the Herring Acoustic survey were combined and augmented to include a broad array of measurements of the pelagic ecosystem during the 3 -19 November 2014 time period.

Operational objectives of this cruise were to:

- (1) collect underway data using TSG, SCS, and ADCP;
- 2) complete CTD and bongo operations at stations throughout area,
- (3) calibrate the EK60 Scientific Sounder,
- (4) conduct acoustic surveys using the EK60 and ME70,
- (5) collect biological data to verify species-specific acoustic measurements using midwater trawls,
- (6) collect butterfish and conduct in situ respirometer experiments while at sea.
- (7) collect samples for the Census of Marine Zooplankton (CMarZ) genetics studies.
- (8) collect samples for aging and genetic analyses of fish larvae and eggs.

- Collect underway data using a TSG, fluorometer, SCS, EK-60 Scientific Sounder and ADCP

- Gather data on trends in ocean acidification and nutrient levels by collecting seawater samples at various depths with a rosette water sampler at predetermined fixed locations.

METHODS

The survey consisted of 155 stations at which the vessel stopped to lower instruments over the port side of the vessel from an A-frame and two conductive-wire winches. Of these, 37 were on Georges Bank, 44 were in the Gulf of Maine, 34 were in Southern New England and the remaining 40 stations were in the Middle Atlantic Bight (Figure 1).

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61-cm bongo sampler and a Seabird CTD. The tows were made to approximately 5 meters above the bottom, or to a maximum depth of 200 meters. All plankton tows were conducted at a ship speed of 1.5 – 2.0 knots. Plankton sampling gear consisted of a 61-centimeter diameter aluminum bongo frame with two 335-micron nylon mesh nets and equipped with digital flowmeters that recorded number of revolutions during the tow, both visually and electronically. At the randomly designated Census of Marine Zooplankton (CMarZ) stations a 20-cm diameter PVC bongo frame fitted with paired 165-micron nylon mesh nets was put on the towing wire one half meter above the Seabird CTD with a wire stop and towed together with the large aluminum bongo frame (Figure 2). A similar PVC bongo frame fitted with two 335 micron mesh nets was towed in a similar fashion at most of the remaining plankton stations to collect larval fish and egg samples for genetics and otolith analysis at the Narragansett NEFSC lab. A 45-kilogram bell-shaped lead weight was attached by a 20-centimeter length of 3/8-inch diameter chain below the aluminum bongo frame to depress the sampler. The flat bottomed configuration of the depressor weight made for safer deployment and retrieval of the sampling gear when the boat was rolling in rough seas. No flowmeters were used in the 20-cm bongos. The plankton sampling gear was deployed off the port side of the vessel using an A-frame and a conducting cable winch. After retrieval the large bongo nets were washed down on a table set up on the deck of the side sampling station to obtain the plankton samples, while the small bongos were hung from a hook on a bulkhead in the same area. Both the large and small bongos were washed down with seawater. The 61-centimeter bongo plankton samples were preserved in a 5% solution of formalin in seawater. The CMarZ genetics samples and the genetics and otolith larval fish and egg samples were preserved in 95% ethanol, which was changed once 24 hours after the initial preservation. Tow depth was monitored in real time with a Seabird CTD profiler. The Seabird CTD profiler was hard-wired to the conductive towing cable, providing simultaneous depth, temperature, and salinity for each plankton tow. A Power Data Interface Module (PDIM) signal booster was also used to allow the data transfer at a high baud rate from the Seabird 19+ CTD profiler over the great length of wire (>1600 meters) on the *PISCES* oceanographic winch. Flowmeter revolutions were also monitored in real time through the tow cable. A CTD 9/11 Niskin bottle rosette sampler cast was made at all the fixed stations to

obtain water samples for nutrient analysis, as well as profiles of water temperatures, salinities, and chlorophyll-a and oxygen levels. A fluoroprobe unit was mounted on the array to provide data as to the type of algae present throughout the water column based on the fluorescence observed at different wavelengths and a Laser In-Situ Scattering and Transmissometry (LISST) instrument provided size spectrum analysis of suspended particles in the water column (Figure 3). Both of these units recorded their data internally, which was periodically downloaded during the cruise between stations.

Continuous monitoring of the seawater salinity, temperature and chlorophyll-*a* level, from a depth of 3.7 meters along the entire cruise track was done by means of a thermosalinograph, and a flow-through fluorometer hooked up to the ship's scientific flow-through seawater system. The Scientific Computer System (SCS) recorded the output from both the thermosalinograph, and the fluorometer at 10-second intervals. The data records were given a time-date stamp by the GPS unit. In addition to these sensors, two ImagingFlowCytobot units were plumbed into the flow-through seawater system in the chemistry lab to collect images of diatoms, dinoflagellates and marine ciliates on an independent computer from the Woods Hole Oceanographic Institute (WHOI) (Figure 4).

Midwater trawling was primarily conducted using a Shallow Water Midwater Trawl (SWMT), brought by Mike Jech, the Lead Midwater Scientist (Figure 5). A larger Polytron Midwater Rope Trawl (PMRT) that was brought along as a backup was not used. A 6-foot wide Isaacs Kidd Midwater Trawl (IKMT) was brought along and used once at the beginning of the cruise. This net was fished from the side-sampling station, and equipped with a Seabird CTD 19+ unit to provide real-time depth measurement so the IKMT could be fished to within 10 meters of the bottom (Figure 6). Although easier and faster to deploy and retrieve than the larger SWMT that was fished from the stern, it did not catch any fish, and was not used for the remainder of the cruise.

Two respirometers for measuring oxygen consumption of live fish were set up in the wet lab area of *PISCES*. One respirometer, provided by Grace Saba from Rutgers University, used a small plastic cylinder immersed in a water bath set to the ambient seawater temperature to house a live fish and measure its oxygen consumption. A second respirometer, provided by the Northeast Fisheries Science Center Oceanography Branch, had a more complex setup, placing the live fish in a chamber with an adjustable flow of water going through it (Figure 7). Water temperature for this system was controlled by a chiller unit, but lacked a pump to distribute the cooled water effectively. More information on the respirometer experiments is available in Appendices A and B.

RESULTS

A summary of routine survey activities is presented in Table 1. Areal coverage for the cruise is shown in Figure 1. The NOAA vessel *PISCES* sailed at noon on Monday, November 3 from its berth on Pier 2 of the Newport Naval Station. Calibration of the acoustic sensors was the first task accomplished at an anchorage in Narragansett Bay, across from the Newport Naval Station. After disembarking the calibration personnel via small boat, sampling was started on the eastern portion of the Southern New England area before proceeding to Georges Bank. A favorable

forecast led to the vessel's track being set to cover the southern and central portions of Georges Bank, before turning west to work its way west towards inshore western Gulf of Maine stations when winds and seas picked up on Saturday, November 8. A midwater trawl made with the IKMT near Wilkinson Basin did not catch any fish, but a second midwater trawl made off of Portland Maine using the larger SWMT yielded some one year old herring that appeared viable enough for the oxygen consumption experiments using the respirometers. The SWMT was used for midwater trawls for the remainder of the cruise. Although more cumbersome and slower to deploy than the Isaacs Kidd net, it was smaller and easier to deploy than the still-larger PMRT. Midwater tows made with the Shallow Water Midwater Trawl took about 2 hours in total, and although it never yielded very large numbers of fish, it was able to catch fish in the proper size range for use in the respirometers. The main problem, we learned, would be to keep the fish from undue trauma that jeopardized their viability for the respirometer experiments.

When the weather front moving rapidly away towards the east after the weekend, the *PISCES* was able to head back offshore and sample the northern portion of Georges Bank and the entire Gulf of Maine. With the command running the vessel at 12 to 14 knots in the relatively calm seas, sampling was conducted at every single scheduled station in the Gulf of Maine and Georges Bank, including a station done alongside University of Maine Ocean Observing System Buoy M 0124 on Jordan Basin to collect nutrient samples for comparison with data being provided by the buoy's sensors. There was also enough time for conducting two midwater trawls using the SWMT every day. These tows provided some live fish for the oxygen consumption experiments in the respirometers that were set up in the wet lab of the vessel (Figure 8).

Although the researchers on board were able to set up both respirometers to hold captured fish and collect oxygen consumption data, they were hampered by the difficulties encountered in catching adequate numbers of fish in good enough condition for these experiments. The main problem was that the SWMT lacked an adequate codend for keeping the fish immersed in water during haulback for transfer to a holding tank and then to the respirometers. An improvement in the codend design of this net to include an "aquarium" of adequate size to minimize trauma to the fish would go a long way towards improving the odds of getting more high quality data from the respirometer experiments being conducted on board. Attempts were made during the cruise to remedy this problem, but were not successful (Figure 9).

Work in the northern part of the survey area was completed by Thursday, November 13, when the *PISCES* transited the Cape Cod Canal, and headed into Southern New England waters. Good weather and the decision by the command to continue transits at 12 or more knots allowed the vessel to continue its rapid progress southward, while still getting two midwater trawls daily, along with plankton bongo tows at random stations and rosette casts at all fixed stations. Diversity increased in the midwater trawl catches as the vessel proceeded south. Some of the different fish caught included a seahorse, cutlass fish, puffer fish, a lookdown fish, and even a paper nautilus. The paper nautilus, despite its apparent fragility, was caught alive and in good enough condition to be placed in one of the respirometers for an oxygen consumption experiment.

Continuous monitoring of the water pumped through the scientific seawater system functioned normally throughout the entire cruise, and data from the plumbed-in sensors was collected both

on the SCS and the WHOI computers on board.

Two systems that developed malfunctions during the cruise were the LISST on the rosette, which stopped turning itself off when casts were completed, and also developed a problem with its pressure sensor. The electronic flowmeters on the 61 cm bongo frames stopped functioning in mid-cruise and were replaced with conventional analog, non-electronic models. It was later found that the submersible canister housing the circuitry for these flowmeters had developed a leak which damaged the circuit board for transmitting their data through the tow wire.

An educational component to the survey included a project from two Rhode Island schools; the Davisville Middle School and Prout High School, where students submitted highly decorated Styrofoam cups and manikin heads for an experiment documenting the effect of water pressure on this material. Placed in two mesh bags that were secured to the bottom of the Niskin bottle water sampling array, the cups and heads were submerged 36 times down to depths of up to 500 meters, shrinking them to a fraction of their former size (Figure 10).

Winds picked up suddenly during the last two days of the cruise, forcing cancellation of an attempted midwater trawl shortly before dawn on Monday morning, November 17, and the dropping of a bongo tow at one of the random stations (7-MAB-1) further to the east, making this the only missed station of the entire cruise. The *PISCES* was able to continue working by moving further south to one of the fixed-position rosette stations and added a bongo tow to it. All subsequent MAB stations were completed prior to docking in Little Creek, Norfolk, Virginia at around 1600 on Wednesday, November 19, marking the end of the PC1405 Fall Northeast Pelagic-Ecosystem Monitoring Survey.

DISPOSITION OF SAMPLES AND DATA

All samples and data, except for the zooplankton genetics samples, the University of Maine nutrient samples, and the Seabird CTD data, were delivered to the Ecosystem Monitoring Group of the NEFSC, Narragansett, RI, for quality control processing and further analysis. The zooplankton genetics samples were delivered to Nancy Copley of the Woods Hole Oceanographic Institute. The nutrient samples were taken by Maura Thomas to the University of Maine. The CTD data were delivered to the Oceanography Branch of the NEFSC, Woods Hole, MA.

SCIENTIFIC PERSONNEL

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Table 1. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
1	1	11/4/2014	41.4117	-71.25	25.3	BON/CTD
2	2	11/4/2014	41.33	-71.242	31.1	BON/CTD
3	3	11/4/2014	41.18	-71.172	36.7	BON/CTD
1	4	11/4/2014	41.1083	-70.627	42	CTD PROFILE 911+, NUT
4	5	11/4/2014	41.0817	-70.093	19.8	BON/CTD, 2B3
5	6	11/4/2014	40.6667	-69.927	50	BON/CTD, 2B1
6	7	11/4/2014	40.085	-69.59	101.7	BON/CTD
7	8	11/4/2014	40.1667	-69.253	97.3	BON/CTD, 2B3
8	9	11/4/2014	40.415	-69.333	75.2	BON/CTD, 2B3
9	10	11/4/2014	40.75	-69.253	53.7	BON/CTD, 2B1
2	11	11/4/2014	40.9	-69.162	66.9	CTD PROFILE 911+, NUT
10	12	11/5/2014	40.415	-68.677	85.5	BON/CTD, 2B3
11	13	11/5/2014	40.3315	-68.263	147	BON/CTD, 2B1
3	14	11/5/2014	40.2467	-67.692	994	CTD PROFILE 911+, NUT
4	16	11/5/2014	40.38	-67.687	251.6	CTD PROFILE 911+, NUT
12	17	11/5/2014	40.4967	-67.338	154.3	BON/CTD, 2B1
13	18	11/5/2014	40.6617	-67.743	77.6	BON/CTD, 2B3
14	19	11/5/2014	40.6617	-67.833	81.3	BON/CTD, 2B1
15	20	11/5/2014	40.7467	-67.497	86.8	BON/CTD, 2B3
5	21	11/5/2014	40.9233	-67.705	65.2	CTD PROFILE 911+, NUT
16	22	11/5/2014	41	-67.755	55.5	BON/CTD, 2B3
17	23	11/5/2014	41.255	-68.003	47	BON/CTD, 2B1
18	24	11/5/2014	41.2517	-67.675	36.8	BON/CTD, 2B3
19	25	11/5/2014	41.1667	-67.593	52	BON/CTD, 2B3
20	26	11/6/2014	41.33	-67.253	49.3	BON/CTD, 2B3
21	27	11/6/2014	41.0867	-67.253	63.5	2B1
22	27	11/6/2014	41.0817	-67.252	63.8	BON/CTD
	28	11/6/2014	41.06	-67.24	64	MID-WATER TRAWL
23	29	11/6/2014	40.92	-67.092	82.9	BON/CTD, 2B3
24	30	11/6/2014	40.9183	-66.842	90.5	BON/CTD, 2B3
25	31	11/6/2014	41.0083	-66.827	74.3	BON/CTD, 2B3
26	32	11/6/2014	41.0883	-66.835	73.9	BON/CTD, 2B3
27	33	11/6/2014	41.16	-66.758	69.4	BON/CTD, 2B3
28	34	11/6/2014	41.0033	-66.512	111.3	BON/CTD, 2B3
29	35	11/6/2014	40.9167	-66.098	290.3	BON/CTD, 2B3

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
30	35	11/6/2014	40.91	-66.11	229.3	CTD 19+ WATER CAST CAL
31	36	11/6/2014	41.1517	-66.313	314.3	BON/CTD, 2B3
32	36	11/6/2014	41.155	-66.307	278.3	CTD 19+ WATER CAST CAL
33	37	11/6/2014	41.5633	-66.255	90.1	BON/CTD, 2B3
34	38	11/6/2014	41.5717	-66.908	64.9	BON/CTD, 2B3
35	39	11/6/2014	41.5767	-67.168	51.1	BON/CTD, 2B1
36	40	11/6/2014	41.5	-67.585	41.6	BON/CTD, 2B3
6	41	11/6/2014	41.4767	-67.685	41.3	CTD PROFILE 911+, NUT
37	42	11/7/2014	41.4533	-68.145	50.2	BON/CTD, 2B3
38	43	11/7/2014	41.4183	-68.815	137	BON/CTD, 2B3
	44	11/7/2014	41.4817	-69.017	149.7	MID-WATER TRAWL
39	45	11/7/2014	41.8367	-69.827	74.1	BON/CTD, 2B3
40	46	11/7/2014	41.995	-69.673	190.2	BON/CTD, 2B1
41	47	11/7/2014	42.08	-70.083	31.2	BON/CTD, 2B3
42	48	11/7/2014	42.41	-69.907	184	BON/CTD, 2B3
43	49	11/7/2014	42.5017	-69.66	258.6	BON/CTD, 2B3
44	49	11/7/2014	42.5017	-69.652	241.3	CTD/IKMT
7	49	11/7/2014	42.5	-69.67	255.5	CTD PROFILE 911+, NUT
45	50	11/7/2014	42.7433	-69.493	195.3	BON/CTD, 2B3
46	51	11/8/2014	43.5833	-70.150	27.2	BON/CTD, 2B3
	52	11/8/2014	43.5083	-70.088	47.6	MID-WATER TRAWL
47	53	11/8/2014	43.0267	-70.163	171.1	BON/CTD, 2B1
8	54	11/8/2014	42.9967	-70.423	101.5	CTD PROFILE 911+, NUT
9	55	11/8/2014	42.4183	-70.612	86.3	CTD PROFILE 911+, NUT
48	55	11/8/2014	42.4133	-70.612	85.4	BON/CTD, 2B3
10	56	11/8/2014	42.3483	-70.482	95.6	CTD PROFILE 911+, NUT
11	57	11/8/2014	42.3117	-70.285	34.1	CTD PROFILE 911+, NUT
	58	11/8/2014	42.2883	-69.940	154.6	MID-WATER TRAWL
49	58	11/8/2014	42.2883	-69.923	184.9	CTD 19+ WATER CAST CAL
50	59	11/9/2014	42.3317	-68.675	197.5	BON/CTD, 2B1

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
51	61	11/9/2014	42.8267	-68.748	206.7	BON/CTD, 2B3
52	62	11/9/2014	42.8367	-68.673	193.6	BON/CTD, 2B1
53	63	11/9/2014	42.5833	-68.177	189.6	BON/CTD, 2B3
54	64	11/9/2014	42.2483	-67.757	232	BON/CTD, 2B3
55	64	11/9/2014	42.2317	-67.750	228.8	CTD 19+ WATER CAST CAL
56	65	11/9/2014	42.17	-67.677	188.9	BON/CTD, 2B3
	66	11/9/2014	42.0417	-67.675	112	MID-WATER TRAWL
12	67	11/9/2014	42.0133	-67.687	68.4	CTD PROFILE 911+, NUT
57	68	11/9/2014	41.9	-67.633	36.3	BON/CTD, 2B3
58	69	11/9/2014	42.085	-67.013	61.4	BON/CTD, 2B3
59	69	11/10/2014	42.0833	-67.007	62	CTD/IKMT
60	70	11/10/2014	41.9167	-66.260	85.9	BON/CTD, 2B3
13	71	11/10/2014	41.7483	-65.455	1463.5	CTD PROFILE 911+, NUT
14	72	11/10/2014	42.2217	-65.768	222.1	CTD PROFILE 911+, NUT
61	72	11/10/2014	42.215	-65.772	221.8	BON/CTD, 2B3
62	73	11/10/2014	42.5767	-65.262	101	BON/CTD, 2B3
63	74	11/10/2014	42.6617	-65.917	81.8	BON/CTD, 2B1
64	75	11/10/2014	42.4983	-66.490	261.2	BON/CTD, 2B3
65	75	11/10/2014	42.4983	-66.507	265.1	CTD 19+ WATER CAST CAL
15	76	11/10/2014	42.4183	-66.995	364	CTD PROFILE 911+, NUT
66	76	11/10/2014	42.4133	-66.992	363.2	BON/CTD, 2B3
	76	11/10/2014	42.4583	-67.080	362.9	MID-WATER TRAWL
67	77	11/11/2014	42.575	-67.247	288.2	BON/CTD, 2B3
68	77	11/11/2014	42.575	-67.263	289.7	CTD 19+ WATER CAST CAL
69	78	11/11/2014	42.83	-66.597	171.3	BON/CTD, 2B3
16	79	11/11/2014	43.0233	-66.347	134.6	CTD PROFILE 911+, NUT
70	80	11/11/2014	43.105	-66.745	157.9	CTD PROFILE 19/19+,
	80	11/11/2014	43.0983	-66.697	116.1	MID-WATER TRAWL
71	81	11/11/2014	43.1617	-67.080	183.8	BON/CTD, 2B3
72	82	11/11/2014	43.165	-67.330	185.2	BON/CTD, 2B3
73	83	11/11/2014	43.3283	-67.418	190	BON/CTD, 2B3
74	84	11/11/2014	43.165	-67.667	185.8	BON/CTD, 2B3
17	85	11/11/2014	43.0333	-67.695	184.4	CTD PROFILE 911+, NUT
75	86	11/11/2014	43.25	-68.260	193.9	BON/CTD, 2B3

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
18	87	11/11/2014	43.395	-67.717	256	CTD PROFILE 911+, NUT
76	87	11/11/2014	43.3933	-67.708	250.8	BON/CTD, 2B3
19	88	11/11/2014	43.4783	-67.877	273.2	CTD PROFILE 911+, NUT
77	89	11/12/2014	43.6467	-67.410	215	CTD PROFILE 19/19+
	89	11/12/2014	43.635	-67.392	214.9	MID-WATER TRAWL
78	90	11/12/2014	43.9133	-66.677	120.1	BON/CTD, 2B3
79	91	11/12/2014	43.9133	-66.605	87.7	BON/CTD, 2B3
80	92	11/12/2014	44.105	-66.775	124.6	CTD PROFILE 19/19+
	92	11/12/2014	44.0767	-66.782	96.3	MID-WATER TRAWL
81	93	11/12/2014	44.2383	-66.920	173.5	BON/CTD, 2B1
20	94	11/12/2014	44.48	-67.222	88.5	CTD PROFILE 911+, NUT
21	95	11/12/2014	44.2017	-67.692	103.5	CTD PROFILE 911+, NUT
82	96	11/12/2014	44.1667	-67.832	128.8	BON/CTD, 2B3
22	97	11/12/2014	43.7733	-68.663	113.9	CTD PROFILE 911+, NUT
83	98	11/12/2014	43.3333	-69.325	168.6	BON/CTD, 2B3
84	99	15:57.0	43.245	-69.493	137.1	BON/CTD, 2B3
	99	11/13/2014	43.22	-69.583	159.9	MID-WATER TRAWL
85	100	11/13/2014	42.48	-70.262	94.3	CTD PROFILE 19/19+
	100	11/13/2014	42.495	-70.298	128.8	MID-WATER TRAWL
86	101	11/13/2014	42.33	-70.407	93.8	BON/CTD, 2B3
87	102	11/13/2014	41.005	-71.577	45.3	BON/CTD, 2B3
88	103	11/13/2014	40.8433	-71.585	59.7	BON/CTD, 2B3
	103	11/13/2014	40.8083	-71.468	60.3	MID-WATER TRAWL
89	104	11/13/2014	40.7483	-71.092	58.1	BON/CTD, 2B3
90	105	11/14/2014	40.5117	-71.032	76.4	BON/CTD, 2B1
23	106	11/14/2014	40.6683	-70.627	61	CTD PROFILE 911+, NUT
	106	11/14/2014	40.6633	-70.598	60.9	MID-WATER TRAWL
91	107	11/14/2014	40.7467	-70.325	49.1	BON/CTD, 2B3
92	108	11/14/2014	40.5783	-70.405	62.1	BON/CTD, 2B3
93	109	11/14/2014	40.2517	-70.247	96.6	BON/CTD, 2B3
94	110	11/14/2014	39.985	-70.087	186.9	BON/CTD, 2B3
24	111	11/14/2014	39.8383	-70.613	812	CTD PROFILE 911+, NUT
25	112	11/14/2014	40.03	-70.605	180.5	CTD PROFILE 911+, NUT

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
95	113	11/14/2014	40.2483	-71.012	117.9	BON/CTD, 2B1
96	114	11/14/2014	40.2433	-71.402	85.5	BON/CTD, 2B3
97	115	11/14/2014	40.1633	-71.733	81.2	BON/CTD, 2B3
98	116	11/14/2014	39.5833	-72.080	204	CTD 19+ WATER CAST CAL
99	116	11/14/2014	39.58	-72.085	180	BON/CTD, 2B3
	116	11/15/2014	39.58	-72.097	211.4	MID-WATER TRAWL
100	117	11/15/2014	39.5	-72.748	64.2	BON/CTD, 2B1
101	118	11/15/2014	39.58	-72.870	64.1	CTD PROFILE 19/19+
	118	11/15/2014	39.5833	-72.848	62	MID-WATER TRAWL
102	119	08:35.0	39.655	-72.988	61.8	BON/CTD, 2B3
103	120	11/15/2014	39.795	-73.062	59.9	BON/CTD, 2B3
104	121	11/15/2014	39.905	-73.167	55.1	BON/CTD, 2B3
105	122	11/15/2014	40.0783	-72.838	52.4	BON/CTD, 2B3
106	123	11/15/2014	40.7417	-72.505	31.9	BON/CTD, 2B3
	123	11/15/2014	40.7167	-72.547	32.5	MID-WATER TRAWL
107	124	11/15/2014	40.6667	-72.737	32.6	BON/CTD, 2B3
108	125	11/15/2014	40.325	-73.903	21.6	BON/CTD, 2B3
109	126	11/15/2014	40.175	-73.902	19.1	BON/CTD, 2B3
110	127	11/16/2014	39.9183	-73.588	29.4	BON/CTD, 2B3
111	128	11/16/2014	39.6667	-73.257	41.6	BON/CTD, 2B3
	128	11/16/2014	39.72	-73.325	39.5	MID-WATER TRAWL
112	129	11/16/2014	39.665	-73.572	35.2	BON/CTD, 2B1
26	130	11/16/2014	39.7067	-73.993	27.7	CTD PROFILE 911+, NUT
113	131	11/16/2014	39.5217	-74.178	19.7	BON/CTD, 2B3
114	132	11/16/2014	39.4967	-73.590	38.3	BON/CTD, 2B3
27	133	11/16/2014	39.3617	-73.395	49.6	CTD PROFILE 911+, NUT
115	134	11/16/2014	39.2517	-73.333	54.7	BON/CTD, 2B1
116	135	11/16/2014	39.2483	-73.007	72	BON/CTD, 2B3
28	136	11/16/2014	39.06	-72.750	138.4	CTD PROFILE 911+, NUT
29	137	11/16/2014	39.0117	-72.585	1014.2	CTD PROFILE 911+, NUT
117	138	11/16/2014	38.83	-73.070	90.7	BON/CTD, 2B1

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	**SiteID/** STA#	**Date** GMT	**Latitude** (dd)	**Longitude** (dd)	**Bottom** Depth(m)	**Operation**
118	139	11/16/2014	38.7467	-73.578	63.4	BON/CTD, 2B3
119	140	11/16/2014	38.5867	-73.742	61	BON/CTD, 2B3
120	141	11/17/2014	38.8283	-74.077	46.2	BON/CTD, 2B3
	141	11/17/2014	38.8	-74.108	46.9	MID-WATER TRAWL
121	142	11/17/2014	38.8283	-74.240	42.6	BON/CTD, 2B3
122	143	11/17/2014	38.7133	-74.658	26	BON/CTD, 2B1
123	144	11/17/2014	38.425	-74.840	21.2	BON/CTD, 2B3
124	145	11/17/2014	38.3417	-74.755	27.2	BON/CTD, 2B3
125	146	11/17/2014	38.1683	-74.517	45.6	BON/CTD, 2B3
	147	11/17/2014	37.9817	-74.152	99.1	MID-WATER TRAWL
30	148	11/17/2014	37.7083	-74.253	111.2	CTD PROFILE 911+, NUT
126	148	11/17/2014	37.7067	-74.247	127	BON/CTD,
31	149	11/17/2014	37.84	-74.578	54.2	CTD PROFILE 911+, NUT;
32	150	11/17/2014	38	-74.953	23.8	CTD PROFILE 911+, NUT
127	151	11/17/2014	37.5067	-74.757	52.7	BON/CTD
128	152	11/17/2014	37.4233	-74.752	49.7	BON/CTD
129	153	11/17/2014	37.495	-75.322	25.7	BON/CTD
130	154	11/17/2014	37.4233	-75.407	26.8	BON/CTD
131	155	11/18/2014	37.1733	-75.088	36.7	BON/CTD
132	156	11/18/2014	37.015	-75.277	33.5	BON/CTD
133	157	11/18/2014	36.4183	-75.410	28.9	BON/CTD,
33	158	11/18/2014	36.005	-75.175	35.3	CTD PROFILE 911+, NUT
34	159	11/18/2014	35.9883	-75.522	22.2	CTD PROFILE 911+, NUT
134	160	11/18/2014	35.9183	-75.415	23.5	BON/CTD, 2B1

Table 1 cont. Summary of sample activities conducted at 155 stations at which the *PISCES* stopped To lower instruments over the side during Cruise No. PC 1405. Latitude and longitude are shown in decimal degrees. BON/CTD=61 cm bongo Standard Protocol, CTD PROFILR 911+ =fixed station, 2B3=335 micron mesh 20 cm bongo 2B1=165 micron mesh 20 cm bongo. NUT=nutrients.

CTD Cast#	SiteID/ STA#	Date GMT	Latitude (dd)	Longitude (dd)	Bottom Depth(m)	Operation
135	161	11/18/2014	35.5033	-75.253	29.1	BON/CTD, 2B3
136	162	11/18/2014	35.5833	-74.928	49.3	BON/CTD, 2B3
35	163	11/18/2014	35.9983	-74.775	400	CTD PROFILE 911+, NUT
137	164	11/18/2014	36.0067	-74.730	749.4	BON/CTD, 2B3
36	165	11/18/2014	36.0033	-74.668	1259.2	CTD PROFILE 911+, NUT
	166	11/18/2014	36.1567	-74.793	142.3	MID-WATER TRAWL
138	167	11/18/2014	36.3367	-74.857	76.1	CTD PROFILE 19/19+
	167	11/19/2014	36.3467	-74.897	79.6	MID-WATER TRAWL
139	168	11/19/2014	36.5317	-74.805	63.1	CTD PROFILE 19/19+
	168	11/19/2014	36.5267	-74.850	44.5	MID-WATER TRAWL
140	169	11/19/2014	36.7433	-74.747	80.3	BON/CTD, 2B3
141	169	11/19/2014	36.7433	-74.755	76.7	CTD 19/19+ WATER CAST PROFILE

TOTALS:	**Std BON/CTD Casts**	**=**	**124**
	2B3 Bongo Casts	**=**	**89**
	2B1 Bongo Casts	**=**	**22**
	CTD PROFILE 911 Casts	**=**	**36**
	Nutrient Casts	**=**	**36**
	Shallow-Water Midwater Trawls	**=**	**21**
	Isaacs Kidd Midwater Trawl	**=**	**1**

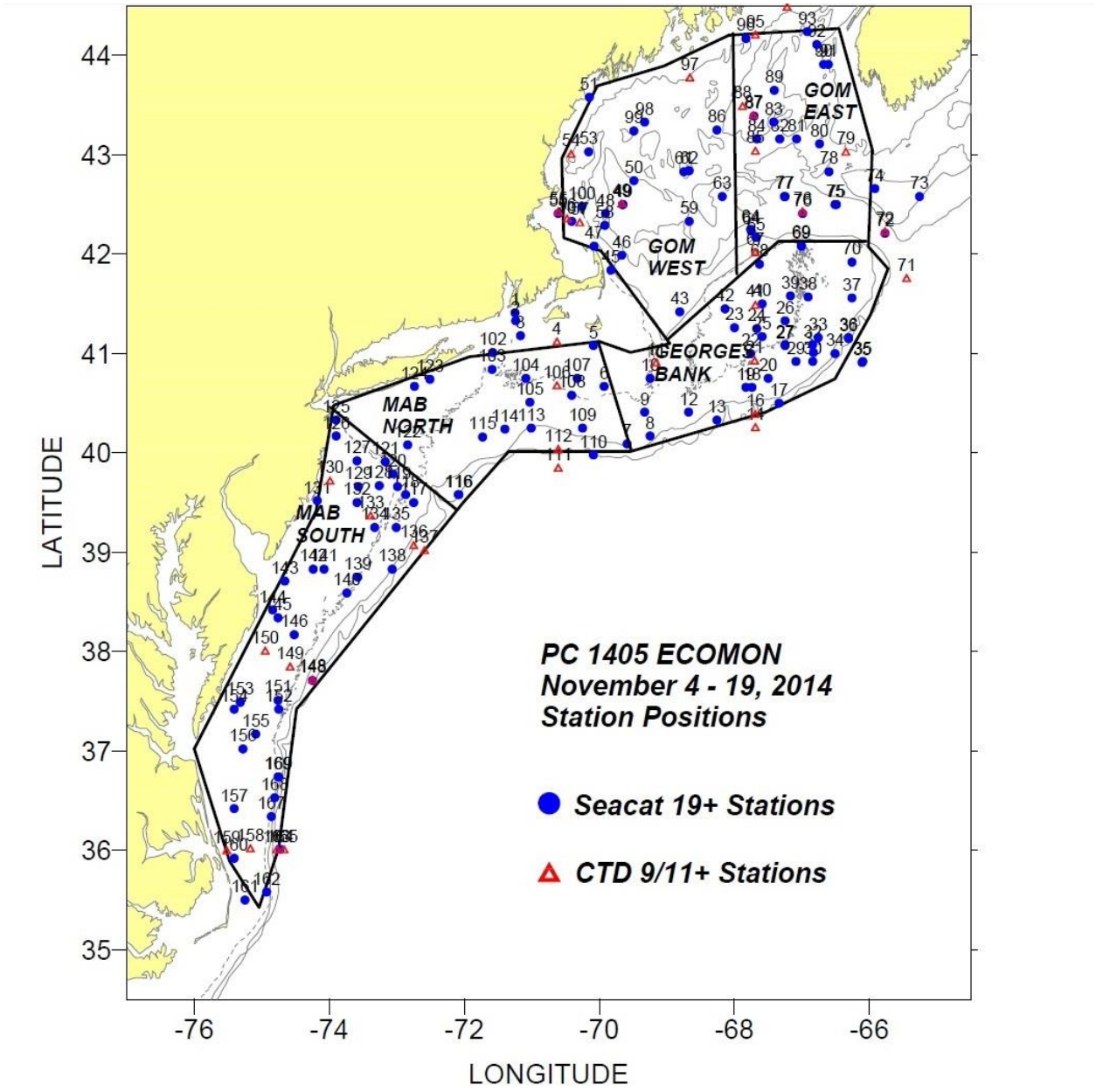


Figure 1. Station locations numbered consecutively for Fall Northeast Pelagic-Ecosystem Monitoring Survey PC 1405.

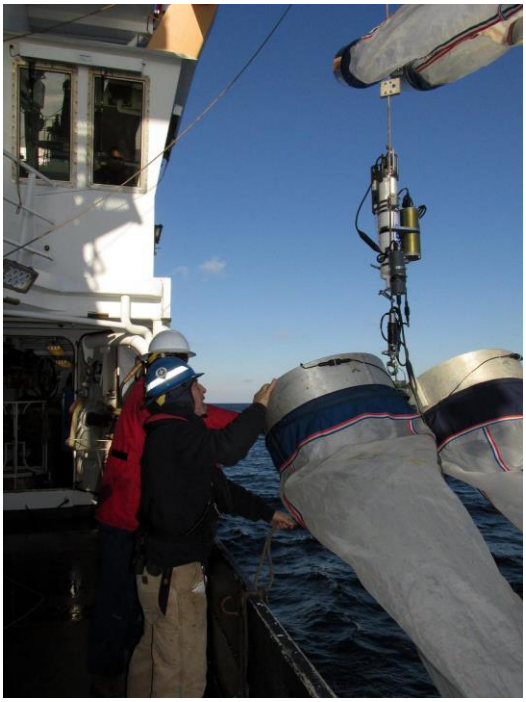
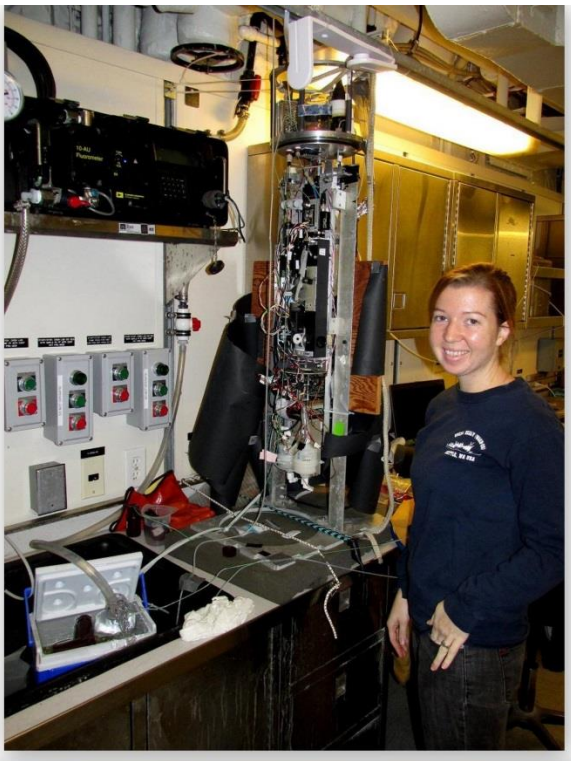


Figure 2. Bongo net array, showing 61 and 20 cm bongo nets, CTD unit with attached PDIM signal booster (bronze cylinder)and electronic flowmeter module (black cylinder) deployed from the side sampling station on *PISCES.*

Figure 3. Niskin bottle rosette with LISST unit visible on left as a large black cylinder and fluoroprobe on right as a small silver cylinder.



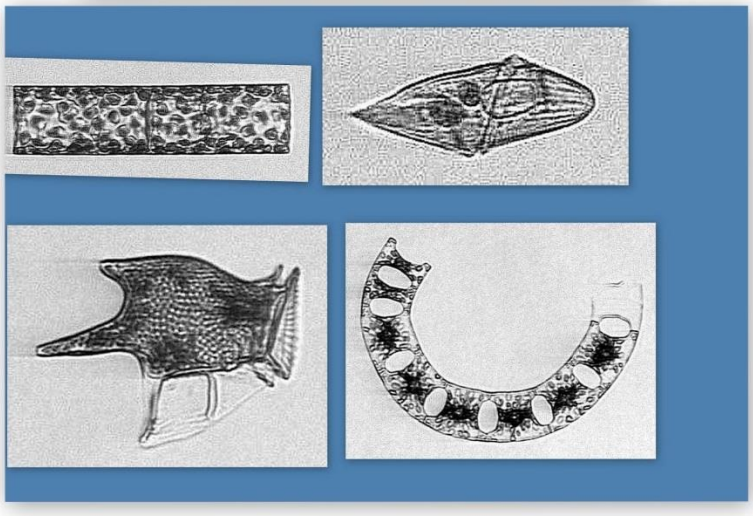


Figure 4. (above) Emily Brownlee from WHOI with Imaging FlowCytoBot unit set up in *PISCES* chemistry lab.

(below) Images of diatoms and dinoflagellates taken by Imaging FlowCytoBot unit.

Figure 5. The Shallow Water Midwater Trawl on the aft deck fitted with a PVC codend "aquarium".

Figure 6. Retrieval of 6 foot wide IKMT net at the side sampling station aboard the *PISCES*.

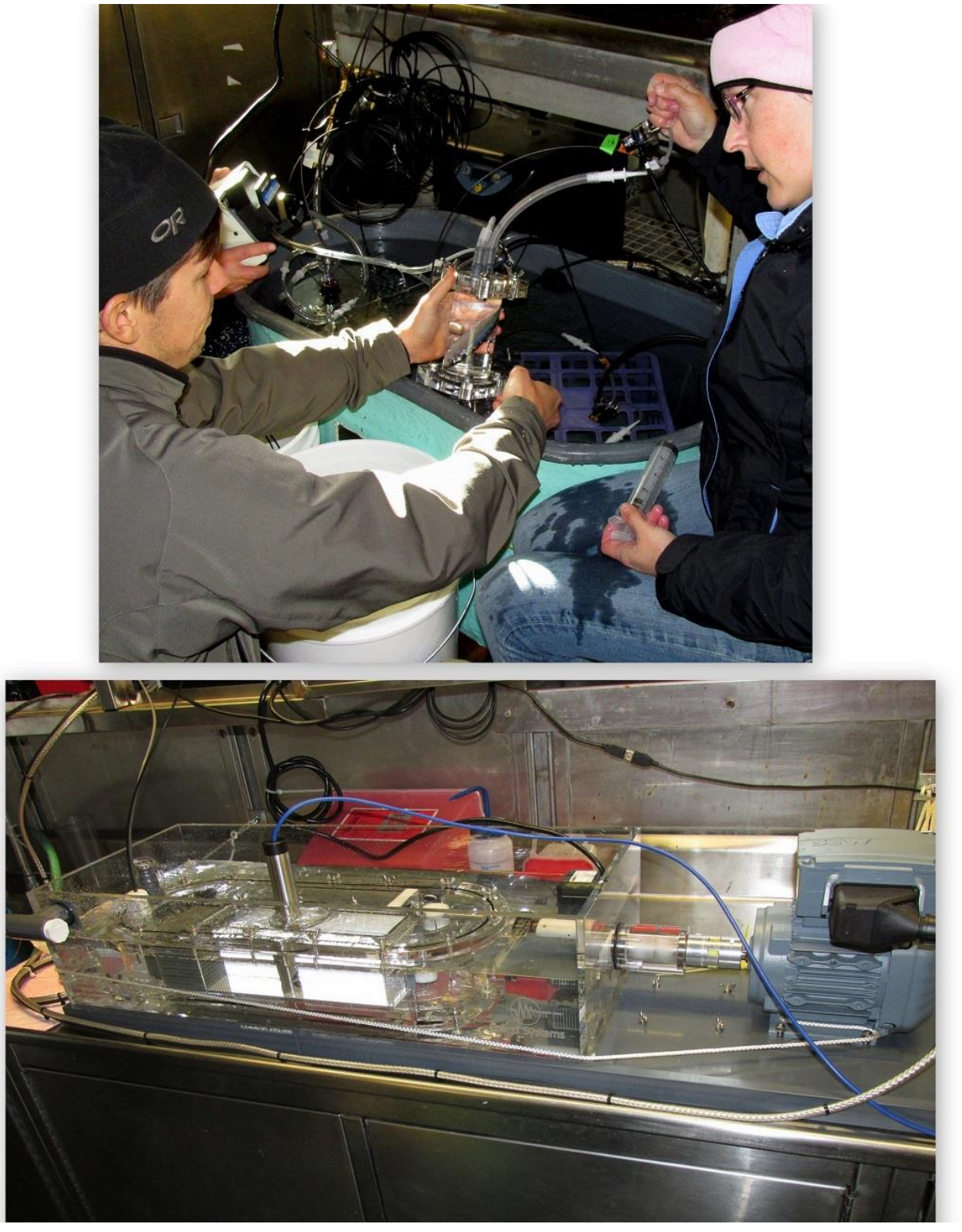


Figure 7.Respirometers aboard PISCES- Above:Rutgers system Below:NEFSC system.

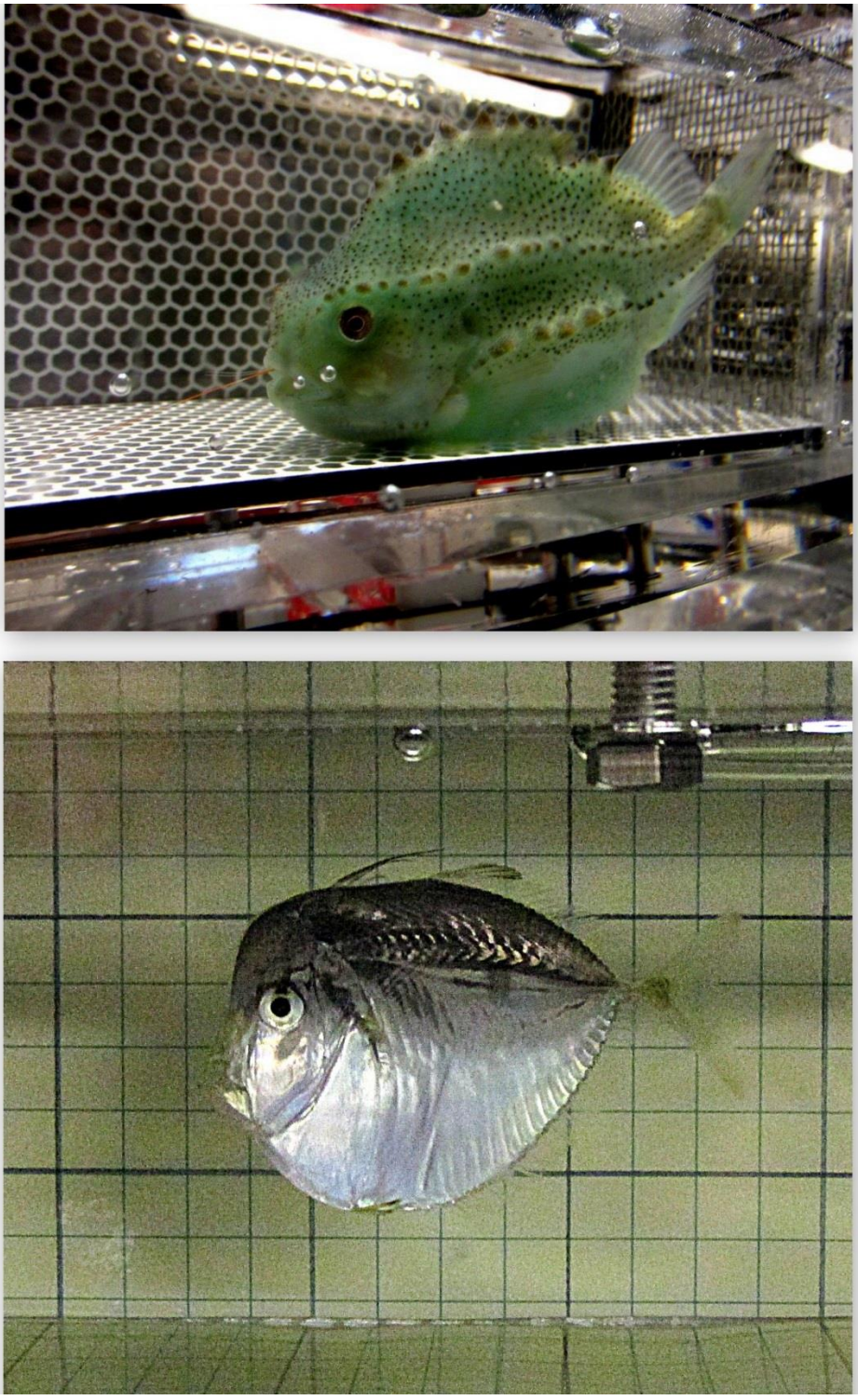


Figure 8. Fish in the NEFSC respirometer system:
Above – lumpfish. Below – lookdown.

Figure 9. Cod end aquaria to reduce trauma to fish captured in a midwater trawl.

Above: First attempt using PVC pipes, held codend open to prevent fish from being crushed, but didn't keep them immersed in water when hauled on deck.

Below: Later attempt kept fish immersed in water, but was too small and/or not placed properly in the net codend, and not many fish entered it. Water entered through slot in front, and exited through mesh on top.

Figure 10. Niskin bottle and CTD 9/11 array with mesh bag holding Styrofoam cups from Davisville Middle School and Prout High School students.

APPENDIX A

At Sea Respirometry

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[2]Rutgers University

Introduction

Metabolic rates of marine organisms can be used to identify optimal pelagic habitat. We sought to develop the techniques to determine basal and active metabolic rates in butterfish under in situ temperature conditions while at sea. The process required, capturing live fish, maintaining them in a holding tank, determining individual characteristics (length, weight, density) and running the fish in the respirometry chambers. All work was conducted aboard the NOAA vessel Pisces, during EcoMon cruise PC1405 from November 3, 2014 through November 19, 2014. Detailed setup and methods are included in the appendix.

Methods

Capturing live fish

Live fish were obtained with a square mid-water trawl, head rope and all sides were 12-16 m, typically towed during night time hours with a quarter inch knotless stretch mesh liner. The cod end was modified to keep fish alive. An open PVC box with no sides (just PVC pipe) was placed inside the cod end to keep the net from closing in on the fish and smothering them. Live fish were caught, but the majority of the fish which came up were dead. A make shift cod end aquarium was constructed out of a heavy duty plastic tote and attached to the top of the PVC box in the net (Figure 1.). The aquarium had an opening in the front face to allow fish to enter, but was half way up the side of the box to ensure that water remained in the box when hauled on deck. A flap of plastic at the mouth opening was folded down into the box to create some turbulence in the aquarium. Half of the top of the box was removed and covered with mesh to allow water to flow through the box, but prevent fish from escaping.

Figure 1. Cod end aquarium constructed on board the Pisces to capture healthy live fish. Water entered through the opening in the front and existed through the mesh on top while towing. Organisms were retained in the aquarium and remained in water when brought on board

Maintaining fish

All live fish from the mid water trawl were transferred to a five gallon bucket of water and then moved to one of two large holding tanks on the back deck. The holding tanks had flowing sea water and an air stone.

Measuring fish

Proper respirometry requires the wet weight, density and other measurements in order to determine total oxygen consumed. This must be done prior to placement in the respirometry chamber. Fish were removed from the holding tank after acclimating for roughly 12 hours with a net or scooped with a bucket. Fish were then transferred by hand to a preweight bucket filled with seawater on a balance to obtain wet weight. The volume of water before and after the fish was placed in the bucket was recorded to obtain volume. The density was then the weight over volume. From there, the fish was either hand placed into the small respirometry chamber or poured into the swim tunnel. A grid was placed on the bottom and back of the swim tunnel to measure length, depth and width without having to handle the fish again.

Respirometry chambers

Two Loligo respirometry chambers were setup on board. Both were run as closed systems. One (termed small chambers henceforth) had the potential to run four chambers simultaneously within a temperature controlled water bath (three fish, one control). The other setup was a 5 liter swim tunnel (termed swim tunnel henceforth) that could measure basal and active metabolic rates by generating a user controlled, continuous current in the respirometry chamber. Intermittent respirometry was conducted on 6 species of organisms, five fish and one cephalopod. Intermittent respirometry consists of a three phase process repeated for up to 24 hours (Figure 2.). In phase one, sea water from a reservoir with an oxygen saturation of over 95% is pumped into the respirometry chamber. The amount of water is equal to five times the volume of the chamber to ensure full flushing of the chamber. In phase two, the chamber is sealed so that no oxygen or seawater is exchanged with the reservoir or anywhere else and the water is allowed to stabilize for a user controlled amount of time to ensure the conditions are the same throughout the chamber (30 sec to 2 min). In phase three, oxygen consumption is measured as the rate of oxygen draw down in the sealed chamber over a user specified amount of time (typically 4 – 20 min). The length of time is determined by the rate of oxygen draw down in the chamber by the individual fish. If the oxygen draw down is low, a longer measurement phase is required to get a good linear relationship between oxygen saturation and time. If the oxygen draw down is rapid, a shorter measurement period is effective. After the user defined amount of time, the measurement is stopped and the chamber is flushed with water from the oxygen saturated reservoir. The phases then continue to cycle for up to 24 hours.

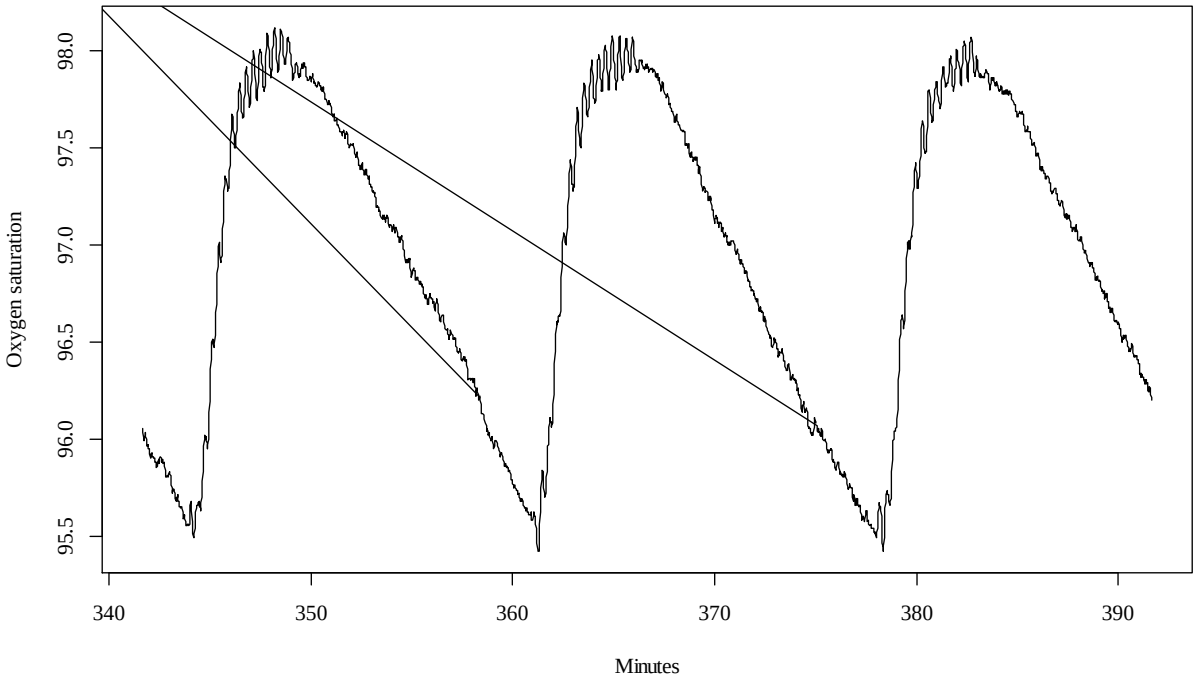

Figure 2. Changes in oxygen saturation during intermittent respirometry. Oxygen levels increase during the flush phase from 95.5% to 98%. The levels stabilize during phase two and then decline during the measurement phase. The cycle is repeated.

Air was pumped through the reservoir to ensure the sea water was >95% saturated (air stone). The chambers were covered to minimize stress on the fish and alteration of behavior from external stimuli (black trash bag). Temperature was recorded along with oxygen and a chiller was used to maintain water temperature. The chamber was filled with water from the holding chamber to minimize acclimation. Full set up details are in the appendix.

Results/Discussion

Capturing live fish

Over thirty mid-water tows were conducted and butterfish were captured in just three tows. Unfortunately the cod end aquarium was placed in the net half way through the cruise and no butterfish were caught while the aquarium was in the cod end. A few squid found their way into the aquarium and appeared in good condition when examined on deck. In general, relatively few organisms made it into the aquarium. The aquarium occupied less than half of the cod end and the opening into the aquarium was relatively small. After a few tows with limited success, a deflector was placed in the cod end ahead of the aquarium. In principle, water and organisms entering the cod end would be deflected up toward the opening of the aquarium. Larger fish would not fit through the opening and smaller fish would enter the aquarium. The exact placement of the deflector may well have been incorrect and could be adjusted. Overall, it appeared the components for a successful cod end aquarium were present in the net, but the exact

design and placement in the net could be improved. In general, we had limited success catching butterfish and even less success keeping them alive. Only three tows had butterfish and most of the fish were dead before the net was even open.

The lack of success could have been due to the gear and possibly time of day. The commercial fishery typically catch butterfish with a bottom trawl and butterfish are typically more concentrated on the bottom during the day. We may have been a little late in the season as the species moves offshore in the colder months or we could have simply been fishing in the wrong locations.

Maintaining fish

Fish transferred to the holding tanks from the trawl net were in varying states of health. Some fish did quite well in the holding tanks and appeared in good condition. The majority of fish however, did not survive. Fish which showed even minor signs of life after removal from the trawl net were placed in the holding tanks. The majority of these fish were heavily stressed and often sank to the bottom of the tank with their operculum barely moving. This occurred for most of the butterfish, hakes and herring. Even fish that appeared in good condition when entering the holding tanks - upright and swimming - were often dead within 12 hours. For example, two juvenile haddock seemed to be doing quite well when placed in the tank, but were dead less than a day later. Dead fish were removed from the holding tank. A few fish, however, did acclimate, remained alive in the holding tank for many days and were released alive after undergoing respirometry measurements.

The holding tanks could be slightly improved, such as covering them to reduce light, but in general it did not appear that the holding tank aspect of the procedure needed major changes.

Measuring fish

Measuring the fish required substantial handling that often left the fish in poor condition. For many fish it is likely that they had not recovered from trawling and the additional handling and placement in the chambers caused a significant amount of stress. While accurate measurements are required for good oxygen consumption estimates, it is likely that the combined stress of trawling and measuring was lethal or put the fish in such a state that it would require days of recovery to get the fish into a healthy state. On most occasions, butterfish that appeared in reasonable condition - were upright and actively swimming in the holding tank - had their condition degrade substantially after being measured and going into the chambers. They were lying on their side and had very high respirometry rates.

For at sea respirometry on sensitive fish like butterfish, an alternative, less precise method may be preferable. We experimented with moving the fish directly from the holding tank to the chamber without touching the fish. The individual was scooped with a bucket and poured into the chamber. Length measurements were taken while the fish was in the chamber, and converted to weight ($W = aL^b$). One study found a relationship with a=0.0055988 and b = 3.2646 (DuPaul and McEachran 1973). Measurements taken on the cruse had a=0.004735, b =3.5299, but had limited numbers of fish, which only ranged from 5.6 cm to 11.5 cm. A mean density could then be used. Improving the condition of fish when they come up in the trawl is more important, but minimizing the stress after they have been caught could help produce reasonable measurements.

Respirometry chamber

In total six species were run and twelve individual experiments were conducted (butterfish, Atlantic sea herring, lumpfish, sandlance, lookdown, paper nautilus). The different fish had a

range of reactions to the respirometry chambers. Butterfish and Atlantic sea herring did poorly in the chambers and appeared in poor condition. They typically had high respirometry rates, 200 to 600 mg O2 /kg hr, suggestion they were highly stressed. Respirometry rates did not decline over time as would be expected as fish acclimate to the chamber. They remained high, even for those fish that remained in the chamber for several hours (> 5 hours). Of the four butterfish and two herring placed in the chambers, one butterfish and one herring were measured for greater than five hours. The other fish were removed due to very poor condition and concerns over imminent death. We attempted to get a butterfish swimming in the swim tunnel and had a moderate current flowing when the fish was poured into the chamber. We were able to get one of the butterfish actively swimming for about sixty seconds before it showed signs of direst. It stopped swimming lay on its side and slid to the back of the tank.

For fish in good condition however, maintaining actively swimming fish that have been caught in a trawl within the swim tunnel seemed entirely feasible. We caught a small lookdown (< 1.0 grams) that was doing well in the holding tank. We transferred it to the swim tunnel without any handling or measuring, scooped it out with a bucket and gently poured it into the chamber. We adjusted the flow velocity in the chamber and were able to get the fish to swim at half a body length per second for 24 hrs without an issue. The fish was extremely small for the size of the chamber, which resulted in poor or basically useless measurements of respiration, but the fish appeared in good condition during the duration of the experiment and when transferred back to the holding tank remained in good health for several days. It was released alive after a number of days on board.

We had a similar experience with a juvenile lumpfish (49 g, 10.8cm). Though the lumpfish did not swim, it was run on three separate occasions, appeared in good condition during all three, appeared in good health in the holding and was released alive. The juvenile lumpfish fish was originally run in the small chambers after acclimating in the holding tank and had a metabolic rate around 90 mg O2/kg hr. After an addition stay in the holding tank it was run in the swim tunnel with an extremely low current flow intended to simply recirculate the water in the chamber. Rates were up at 200 – 250 mg O2/ kg hr and did not decline over the course of the 24 hour experiment. The fish was in the process of consuming a small crustacean, which was not apparent until it was in the chamber and might have altered its metabolism. It had the crustacean in its mouth for the duration of the experiment. After a few more days in the holding tank, the lumpfish was run again in the swim tunnel. The current velocity was increased slightly to ensure the fish oriented properly, but the fish did not swim. It suction cupped to the bottom of the chamber and stayed there. The experiment was run for roughly 18 hours until rough seas required it to be ended. The rates were around 108 mg O2/kg hr (Figure 3.).

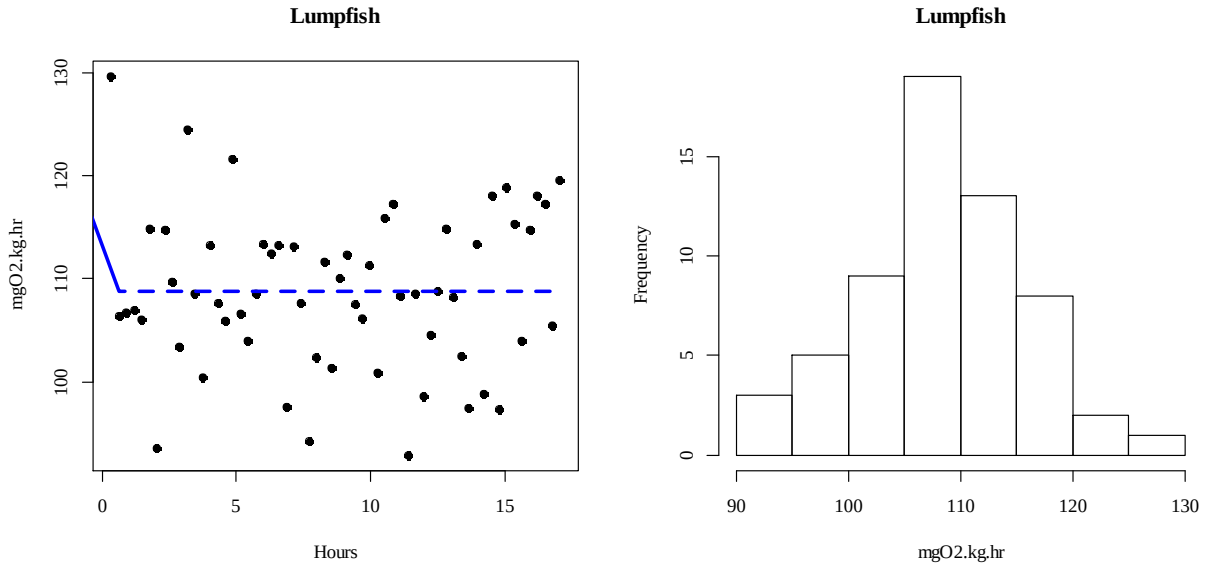

Figure 3 The oxygen consumed for each measurement phase of the final lumpfish experiment over the course of 18 hours.

Conclusion

At sea respirometry is feasible, but the biggest challenge for this project was acquiring and maintaining healthy fish. When the fish were healthy, or appeared healthy, the experiments ran well and the results seemed reasonable. The juvenile lookdown came up in the trawl and was maintained in the swim tunnel, actively swimming for a full day without a problem. The butterfish and herring, even when they were swimming and looked good in the holding tank, were probably never in good condition and the combination of handling stress from the measurements and placement in the chamber was too much for them. The use of a well designed cod end aquarium and increasing the number of butterfish caught with fishing gear designed for and proven successful at catching butterfish would significantly improve the health of the fish and the potential for success. As an intermediate step, capturing fish from pound nets in Narragansett Bay or from day trawlers could be useful for running experiments at the Narragansett Lab.

Early on we had some technical issues, mostly electrical and grounding issues for the swim tunnel and pump and plumping problems for the small chamber. These were largely solved, but could surface again if respirometry was attempted on smaller vessels with less controlled lab space. Rough sea conditions were a challenge for both systems as the fish bang around, potentially affecting the measurements and the open tops slosh water. Taller sides for the swim tunnel will be required for extensive use at sea. The swim tunnel requires a number of components, which all needed to be plugged into separate, grounded, outlets. The original setup with power strips and an ungrounded laptop had a number of feedback issues which caused

major interference with the oxygen and temperature probes. The majority of these issues went away once the components were plugged into independent, grounded outlets. The plumbing and pump setup for the small chambers was a bit finicky and required a watchful eye. One swim tunnel issue that was not resolved was the change in the variability of the oxygen measurement (Figure 4.). The variability around the oxygen measurement would change from a low variability range of about 0.4% (phase range 0.03) to a high variability range of about 1.4% (phase range 0.1) intermittently. We were unable to identify the cause. The high variability made it more difficult to get a good measure of the oxygen consumption, resulting in poor estimates of metabolic rate. Email exchanges with Loligo suggested that the variability levels were acceptable and that the problem may go away with a grounded desktop PC.

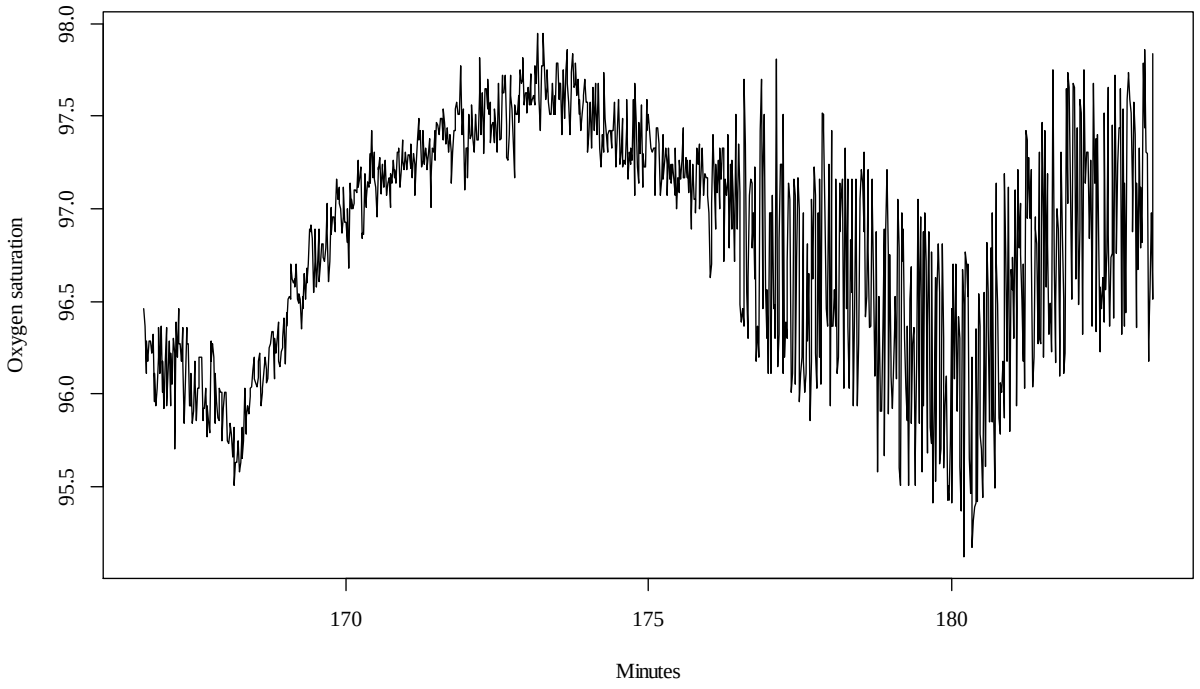

Figure 4. The variability around the oxygen saturation changes dramatically around minute 176, during the measurement phase.

The Loligo system went together reasonably well, however proper setup is required. The majority of the potential issues have been documented and a general procedure for running experiments has been developed. The major bugs have been worked out enabling more detailed questions of experimental design and what questions could be answered. Questions such as whether the experiments should be conducted at constant temperature or follow in situ patterns and how that affects the results are important. Additionally, the size of the chamber limits the experiments to age-1 fish and younger. How does juvenile habitat differ from adult habitat and how does this scale up to help define optimal butterfish habitat.

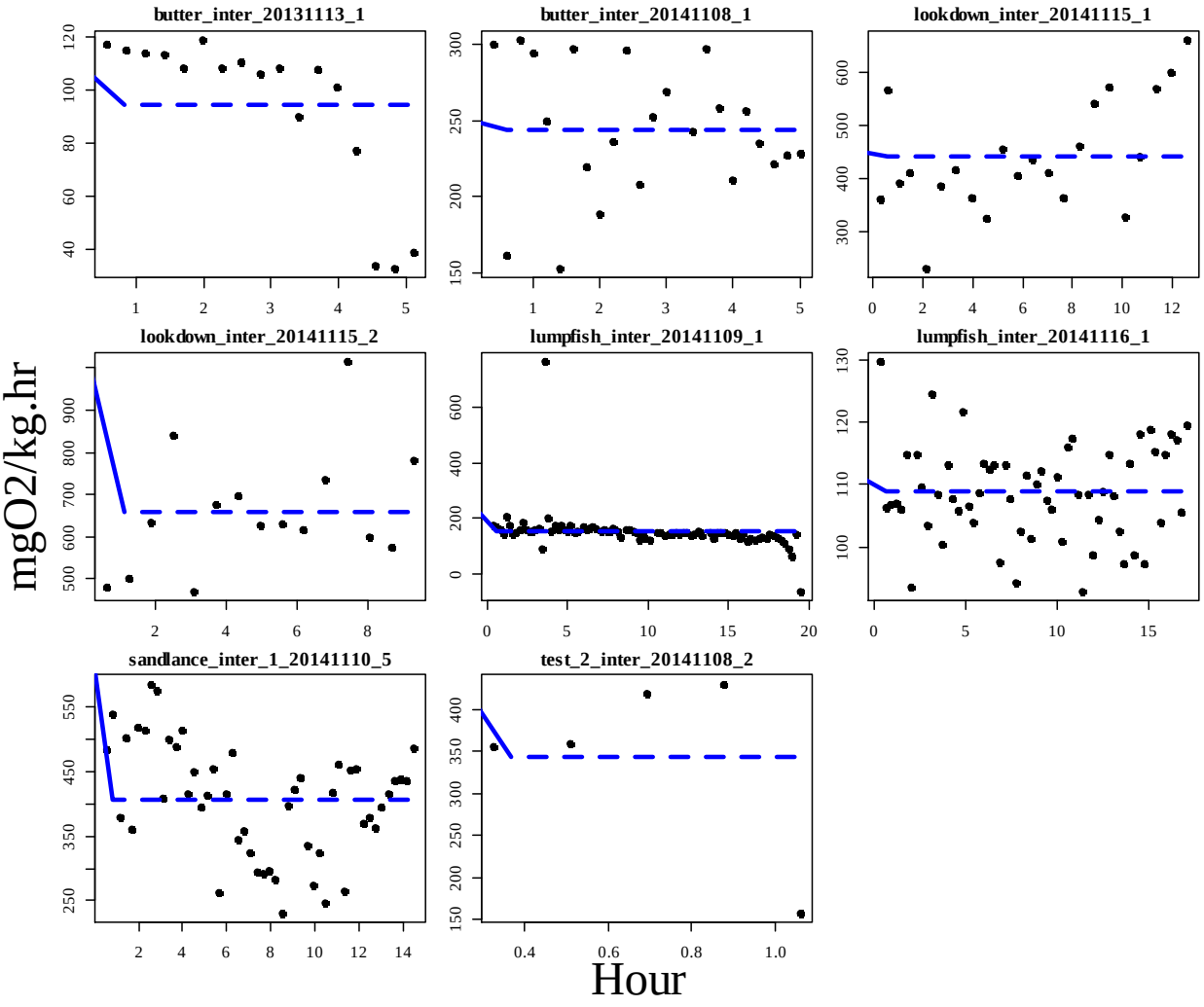

Figure 5. Oxygen consumption over time for the different experiments in the swim tunnel. Test_2 was the Atlantic sea herring.

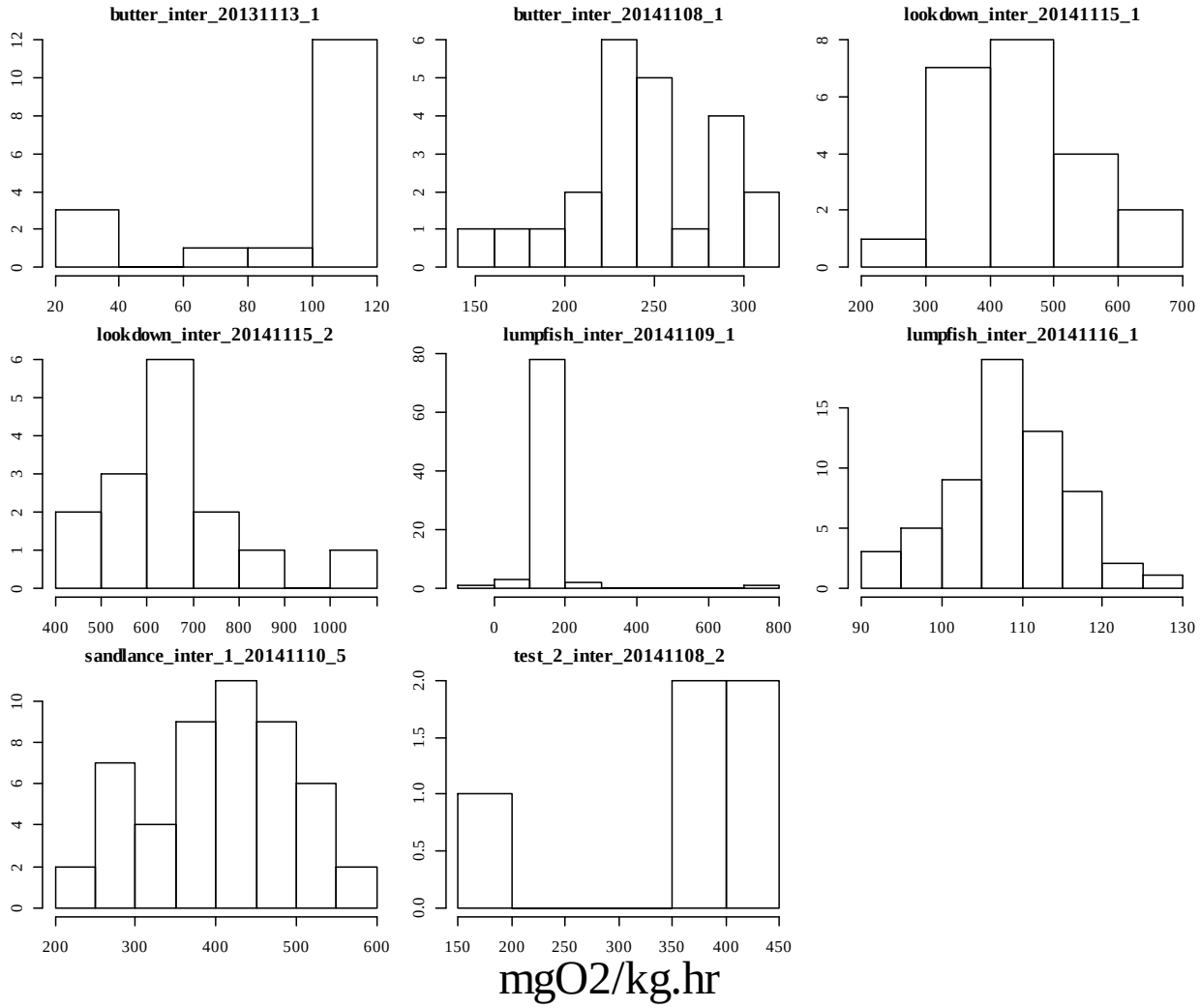

Figure 6. Histogram of the different consumption measurements in the swim tunnel. Test_2 was the Atlantic sea herring.

Species	Mean	Stand Dev
butterfish_inter_20131113_1	94.32	30.13
butterfish_inter_20141108_1	244.07	43.28
lookdown_inter_20141115_1	441.60	104.95
lookdown_inter_20141115_2	657.89	143.73
lumpfish_inter_20141109_1	152.70	73.98
lumpfish_inter_20141116_1	108.77	7.65
sandlance_inter_1_20141110_5	405.76	87.17
herring_2_inter_20141108_2	344.50	109.52

APPENDIX B

Loligo swim tunnel setup procedure

Equipment
Loligo swim tunnel with external motor
Motor controller
DAQ-M
Witrox
    Oxygen probe
    Temperature probe

PC desktop (Windows 7) with Bluetooth capability (or external Bluetooth adapter)
    Laptops should not be used as the PC needs to be well grounded

Power strips/surge protectors
Water jacketed reservoirs for oxygen calibration
Chiller
Chiller pump
Aquarium air pumps (swim chamber and holding tanks)
Dip nets (large and small)
Holding tank
Buckets (large and small)
Balance
Ruler
60 cc syringe
Tubing for chiller and drain
Gas cylinder regulator valve and adaptor
Nitrogen gas cylinder

1. Connect all equipment. Ensure the DAQ-M IS DIRECTLY PLUGGED INTO A GROUNDED OUTLET. Do not plug into a power strip with other components of the system. Plug the motor controller (red box) into a separate grounded outlet. DO NOT PLUG THE MOTOR CONTROLLER INTO A POWER STRIP. The further separated the computer, DAQ-M and motor controller are on separate grounded outlets and/or separate circuits the better. The wiltrox does not have a ground and we currently believe can be plugged in where ever.
We originally set up the system with all the components plugged into the same grounded power strip. All the components worked, but there was interference between the motor controller, the DAQ-M and other components. In this configuration, when the motor controller was turned on, whether run through the computer or run manually, the mouse on the computer (ungrounded laptop) did not work and the temperature changed. This was directly related to the motor controller and was not a problem when the motor controller was turned off. The problem with the mouse and the temperature also ceased when the motor controller was unplugged from the DAQ-M, indicating that it could be used in manual mode without any connection to the computer. Plugging the motor controller directly into a grounded outlet on one circuit; plugging the DAQ-M directly into a grounded outlet on another circuit; plugging the wiltrox and laptop into a power strip and plugging the power strip into a grounded outlet on the same circuit as the

DAQ-M; and sketchily grounding the laptop appeared to be a configuration that worked with minimal interference.
2. Use a grounded desktop. If your PC is not grounded, the motor controller creates interference which alters the temperature (which subsequently alters the oxygen reading)
3. The wiltrox is bluetooth and needs a signal with the PC
4. Make sure the Wiltrox is turned on (green light) and bluetooth is ready to go (flashing blue light). If there is a red light and a green light, turn off the wiltrox by depressing the green light and turn it back on. The light should switch from red to blue flashing.
5. Open the Wiltrox software with all other programs closed. Autoresp should not be open
6. Click automatic detection. If it connects a serial number will appear in the Wiltrox screen. The blue light on the wiltrox box should stop flashing and be solid blue
7. Remember which com port is connected.
8. In the wiltrox program, click device and calibrate. If everything is connected, a temperature and phase reading will appear
9. The wiltrox temperature probe does not need to be calibrated- no two point calibration for wiltrox temperature.
10. Close the wiltrox program
11. Open the autoresp program. The instaCal warning can be ignored. The connection with the instruments through the wiltrox must be made initially with the wiltrox software, but once the connection is established, the wiltrox software is no longer needed and everything comes through the autoresp software
12. In autoresp, change auto configure to DAQ-wifi-1.
13. change data acquisition to DAQ-M and device name to dev1
14. change fiber optic inst. to wiltrox and change the com port to the correct com port from the wiltrox software. The temperature will not show up until the correct com port is selected.
15. click ambient oxygen and ambient temperature on the bottom left of the general tab.
16. If using the wiltrox for temperature it does not get calibrated
17. prepare two tanks, one flushed with N2 gas overnight and one flushed with air overnight.
18. in autoresp, go to the oxygen page for calibration and drop the temp and oxygen probe in the N2 tank, wait for it to stabilize and then hit lock lo.
19. drop the temp and oxy probe into the air tank, wait for it to stabilize, then hit lock hi
20. the calibrations are saved in a AutoResp.conf file automatically. They are present when ever the auto resp software is opened. When opening the wiltrox software it says all calibrations will be deleted, but that is not a problem, but that will not affect the calibrations done while in the Autoresp software.

SWIM Tunnel speed

21. Turn on the motor controller (red machine) by turning the knob to the right. It is a bit challenging.
22. On the bottom of the controller turn the switch to knob.
23. on the face, turn the switch from zero to forward.
24. Turn the knob in the top left till it reads 200 (rpms? micro volts? unclear). This should turn on the motor in the swim tunnel and the water should be moving. If it does not, trouble shoot and make sure everything is connected.
25. Turn the knob back to zero and motor should stop

You do not need to use any of the buttons on the motor controller face. Unclear what they all do, but the motor has more functionality than is needed for the swim tunnel work.

26. on the bottom turn the switch to EXT (external control), leave all other controls the same.
27. In autoresp click on the general tab
28. on the bottom left click on swim tunnel. A new tab should appear.
29. click on the velocity ch1 tab
30. input the correct velocity input channel. This is the input channel from the motor controller (red) to the DAQ-M. We had it plugged into the 3/4 channel and channel 3 was the one that worked.
32. Change input type to tacho.
33. Change velocity control to out1
34. On the second line change output V to 0.5. This should turn on the motor in the swim tunnel and produce values on the motor controller screen. 0.5 output volts was about 171 on the motor controller and a velocity of about 6 cm/s. it could take 10-15 seconds to actually show up on the screen or on the graph.
35. If no signal is going either way, change the switch on the bottom of the motor controller from EXT to knob so that the motor controller has control of the motor.
36. Turn the knob to 200 and get the motor going.
37. In autoresp with input type as tacho or volts, work through the velocity input channels till some signal registers. Even if autoresp is not in control of the motor controller it will still register that it is running. Hopefully this provides some signal. We found that in volts mode. The incorrect input channel all registered 1.4, while the true channel was variable and close to 5.
38. if the signal is still absent, unplug the USB from the computer and plug it back in. Check that the green light is flashing on the DAQ-M. hopefully it connects.
39. We found we could not calibrate the velocity in volts input type, but could in tacho.
40. In autoresp, set input type to tacho and velocity control to out1 and the switch on the bottom of the motor control to EXT.
41. enter 0.5 or some other low value in the output V box.
42. With the external hand held flow meter determine the velocity from that much output V.
43. In the two point calibration box, enter the velocity that output V creates and the output V.
44. Once the rpms stabilize hit the lock lo
45. In the output V on the second line enter a high value like 2.0
46. From the hand held flow meter, enter the velocity and the output V into the bottom line.
47. Once the rpms stabilize, hit the lock hi button.
48. Enter a mid value in output V on the second line 1.0.
49. See if the velocity indicated in autoresp is the same as the velocity from the hand held flow meter. If not, play with all the buttons.

We found that every time we turned on the motor controller with an ungrounded laptop (all laptops are ungrounded I believe) the mouse stopped working and the temperature changed. The motor controller was causing some type of problem. When the motor controller was unplugged from the DAQ-M, the swim tunnel could still be powered manually from the motor controller and the problems with the laptop mouse and temperature went away. Experiments could be done in this mode. The velocity would simply have to be recorded externally to the software as there

was no longer a connection between the computer software and the motor. This is why a desktop should be used.
To correct such this problem, we connected the metal on the motor controller (one of the DAQ-M plugs) to the laptop (outer shield of the vga output) and then connected the laptop to the wall. This mostly grounded the laptop. The temperature signal seemed to return to the correct value and the mouse worked again. A desktop is still recommended.

SETUP DETAILS

Ensure all equipment is plugged into separate wall outlets, no power strips to deal with grounding issues.
Grounded desktop PC
Chiller for temperature control
air stones to maintain oxygen saturation in outer chamber
motor controller velocity on slow 3-7 cm/s, 0.5-0.6 V to recirculate water in the chamber even if not doing swimming experiments. Maybe less for small fish.
When turning on the motor controller the temperature spikes for about 10 sec. This is not an issue and returns to original level.
Cover the tank to keep it dark and so fish does not get disturbed by people moving around it. trash bag or something.
Five min with the 600 L/hr flush pump and a chamber volume of 5.25 L is enough to flush the tank with five times the volume of water which is the recommended amount.
Not sure about the wait period, 30 sec to two min, maybe.
measurement phase should be long enough that a noticeable draw down in oxygen occurs, preferably >5%, but we ran with about 1-2%. Run it for long enough that get a good R^2 and the R^2 hits a threshold. Can monitor this in R^2, right click, current.
Oxygen probe should be inserted till the metal is just visible. Temp probe should be inserted so that the bottom is at the same depth as oxygen probe.
The wing nuts should be very tight, about as tight as you can go without tools, full hand tighten to prevent leaks. When measuring the volume of the chamber by filling it with water, the wing nuts had to be what seemed like over tightened by hand to get it to stop leaking
Fill chamber with water from holding tank to reduce acclimation.
Try to scoop fish with bucket and not net fish if possible.
have grid inside chamber to measure length of fish to decrease handling time before experiment.
Weight fish in bucket of water and get volume by water displacement.

DuPaul, W. D. & J. D. McEachran, 1973. Age and Growth of the Butterfish, *Peprilus tricanthus*, in the Lower York River Chesapeake Science 14(3):205-207.